REACHING FOR THE RIGHT PORTFOLIO STRATEGY: MULTICRITERIA R&D PLANNING PROBLEMS AND HIGH-PERFORMANCE COMPUTING

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ABSTRACT

An application of high-performance computing to the analysis and solution of an R&D portfolio strategy problem is described, A study conducted ten years earlier is revisited and used as a benchmark. A comparison of the two studies illustrates that 695 solutions were superior to the feasible options identified by pairwise comparison in the original study, The results show promise that R&D problems of significant size can be optimized using high-performance computing methods.

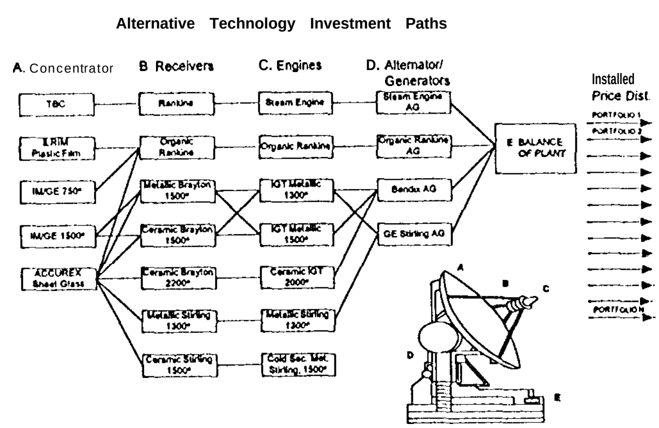
INTRODUCTION

During the past twenty five years there has been considerable research activity revolving around the Research and Development (R&D) project selection problem: "How does (or should) an organization select a portfolio of projects and allocate resources to research and development activities?" The Management Science and Operations Research communities have responded by creating numerous normative and descriptive models ranging from simple scoring techniques to complicated mathematical algorithms [Steele 1988, p. 311 [Czajkowski and Jones 1986, p. 331 [Souder and Mandakovic 1986, p. 291. Many of these techniques involve the solution of large-scale combinatorial problems using heuristic methods, Correspondingly, *one* of the primary barriers to the widespread application of these techniques has been the computational limits of computer technology. However, advances in high-performance computing have expanded the boundary of computing feasible problem solutions, This paper describes a study of R&D portfolio selection with an objective of enumerating *all* feasible solutions to a problem of significant scope using high-performance computing methods.

CASE STUDY: SOLAR THERMAL ENERGY CONVERSION

The case study involved the selection of an R&D portfolio of solar thermal energy technologies competing for utilization in a solar thermal power system [Balbien 19811 [Miles 1984, pp.59-67]. The power system consisted of competing parabolic solar collectors, receivers, engines, and alternator/generators as shown in Figure 1,

FIGURE 1. SOLAR THERMAL ENERGY CONVERSION EXAMPLE



Within each subsystem were a number of potential technology alternatives funded to achieve specific performance requirements, A combined performance and cost model was developed to compute the total installed price of each alternative configuration, Sixteen model parameters and variables were modeled probabilistically using Monte Carlo simulation and 54 cumulative probability distributions were elicited from over 20 technical experts. A total of 15 technology paths were developed that represented the most promising technology development strategies,

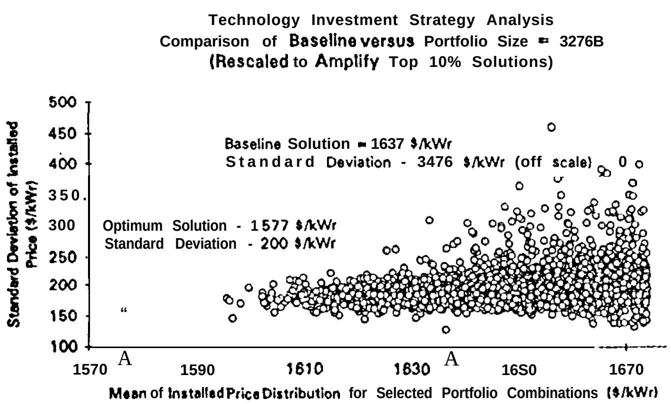
The computer technology at the time of the original study severely limited the solution strategy. The most promising technology paths were compared on a pairwise basis to determine which option was the best investment (based on the minimum installed price), The minimum price obtained across the eight combinations studied was $1637 per rated kilowatt ($/kW,).

The same computer code and data set were transferred to a CRAY Y-MP2E and an additional subroutine module was added to enumerate every possible portfolio strategy combination for the 15 technology paths. Thus, a Monte Carlo simulation was performed for each individual path followed by all combinations of two paths, three paths, and so on for the $2^{15} - 1$ = 32,767 possible portfolios. The simulation was repeated on a local workstation to develop additional benchmarks.

RESULTS

Figure 2 illustrates the results for the top (lowest price) 10% of the 32,767 portfolios by plotting the mean versus standard deviation of the installed price for each portfolio strategy.

FIGURE 2. BASELINE SOLUTION (ORIGINAL) VERSUS ACTUAL (OPTIMAL) SOLUTION



The circles mark the minimum prices and the arrow marks the result of the original study. Note the large number of new points below the prior 'optimal" solution, $1637 $/kW,. Within the 32,767 portfolio strategies, there were 695 portfolios that were lower in price than the original study. The true optimal solution is $1577 $/kW$_r$ -- about 5% less than the estimated solution price in the original study with a 94% *decrease in* the standard deviation. This price difference is significant when distributed across the rated power of the plant.

DISCUSSION AND CONCLUSIONS

This study has indicated that computer advances are making practical R&D portfolio analysis increasingly feasible for expanding portfolio sizes. The present study indicates that complete enumeration of portfolios of up to size 20 is feasible. The transfer of such problems to the parallel processing environment will extend this limit significantly. Furthermore, if the requirement to compute the installed price probability distribution were eliminated (so that only the mean and variance were used), significant reductions in processing time could also be achieved using more direct transformation methods. These and other improvements would serve to enable even larger portfolio sizes.

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